Article • Attention Deficit Hyperactivity Disorder (ADHD) Symptoms Among University Students Associated with Non-Strabismic Binocular Vision Dysfunctions (NSBVDs)

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ABSTRACT

Background: Attention deficit hyperactivity disorder (ADHD) and non-strabismic binocular vision dysfunctions (NSBVDs) are commonly observed in school-age and university students. Due to the similar nature of symptoms, NSBVDs were often misdiagnosed as ADHD in school-age students. Studies related to the association of ADHD symptoms and NSBVDs among university students are limited. This study aimed to find the distribution of ADHD symptoms among university students associated with NSBVDs.

Methods: This prospective cohort study was conducted with 100 university students from different academic departments. In the first phase of the study (conducted by author SAD), a comprehensive eye examination and a detailed binocular vision assessment were performed. In the second phase (conducted by author SS), the screening of ADHD symptoms was carried out with the 18-item ADHD Self-Report Scale-v1.1 (ASRS-v1.1). Both authors were masked concerning the results of either phase to avoid bias. Students with pre-diagnosed learning disability or ADHD were excluded from the study.

Results: Out of 100 students, 70% had some form of NSBVD – convergence insufficiency (30%), accommodative dysfunction (24%), accommodative with vergence dysfunction (13%), and fusional vergence dysfunction (3%). Seventy-one percent of students reported positive ADHD symptoms; most of the students had inattention problems rather than hyperactivity. Fifty-two percent of students were diagnosed with some form of NSBVD and revealed ADHD symptoms.

Conclusion: This study shows that over half of the university students with NSBVDs also reported positive ADHD symptoms. Further study is recommended about the comparison of ADHD symptoms before and after the management of NSBVDs. A complete binocular vision evaluation is suggested for university students with ADHD-like behaviors.

Keywords: attention deficit hyperactivity disorder, convergence insufficiency, non-strabismic binocular vision dysfunctions

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the common neurobehavioral disorders characterized by any one of three types of behaviors—inattention, hyperactivity, and impulsiveness—or a combination of any two of these types.[1] According to a recent survey, the worldwide prevalence of ADHD is 0.1 to 8.1% in children and 0.6 to 7.3% in adults.[1] Several studies have focused on the prevalence of ADHD symptoms in university students, reporting a wide range, from 2% to 15.4%.[2–7] Various self-reported scales such as the Adult ADHD Self-Report Scale-v1.1 (ASRS-v1.1), Conners' Adult ADHD Rating Scale–Self-Report: Long Version (CAARS), and Brown ADD Scales are available for the screening of ADHD symptoms.[3] ASRS-v1.1 and CAARS are based on the Diagnostic and Statistical Manual of Mental Disorders-4th edition-Text Revision (DSM-IV-TR) criteria.[3]

Association between ocular problems and ADHD is well established.[8–15] Ametropia (83%),[13] astigmatism (24%),[8] binocular vision disorder (53%),[8] subnormal stereovision (26%),[8] and convergence insufficiency (CI) (15%[11] to 35%[14]) are some of the ocular problems found to be consistent in patients with ADHD. Borsting et al.

reported a higher frequency of ADHD-like behaviors in children with symptomatic CI or accommodative dysfunction.[10] A decrease of ADHD-like behaviors in children with symptomatic CI following treatment with office-based vergence/accommodative therapy was reported.[15] A similarity of symptoms between CI and ADHD was detected. For example, inability to concentrate while reading or poor reading speed in CI is almost identical to one of the ADHD behaviors, inability to complete assignments and difficulty in concentrating in class.[10] According to Borsting et al., the mechanism behind this CI vs. ADHD association might be that an individual with CI or accommodative dysfunction already has a maldeveloped attention mechanism in the central nervous system. This results in poor coordination of the oculomotor system as well as manifestation of ADHD-like behaviors.[10]

Non-strabismic binocular vision dysfunctions (NSBVDs) are commonly found in children and young adults and are broadly classified into accommodative dysfunctions (ADs) [accommodative insufficiency (AI), ill-sustained accommodation, accommodative infacility (AIF), accommodative spasm or accommodative excess (AE), and accommodative paralysis] and vergence dysfunctions [CI, convergence excess, divergence insufficiency, divergence excess, fusional vergence dysfunction (FVD), basic esophoria, and basic exophoria].[16] The association between ADHD and NSBVDs has been studied in school-age students; an association between CI and ADHD was reported.[10,14,15] A few investigators have reported that NSBVDs, particularly CI, are often misdiagnosed as ADHD.[9–11] Therefore, a detailed binocular vision evaluation has been recommended for school-age students with ADHD-like behaviors.[14,17] The evidence concerning similar ADHD–NSBVD associations in university students is limited. Migrant et al. found an association between ADHD, CI, and dyslexia by using ASRS-v1.1, the Convergence Insufficiency Symptom Survey (CISS), and the Adult Reading History Questionnaire for dyslexia, respectively, in university students.[18] The study was mainly focused on CI, and the association of ADHD or dyslexia with other types of NSBVDs was not addressed. Wilmer et al., in 37 college students, suggested that post-near-work phorias predict more ADHD related symptoms due to the oculomotor imbalance immediately after continued near work.[12] University students are actively involved in near work, especially using digital devices, and often complain about asthenopic symptoms.[19] Several studies have demonstrated significant amounts of various types of NSBVD in university students.[20,21] As mentioned earlier, university students exhibit ADHD symptoms; hence, investigation of the ADHD–NSBVD association in that population will provide a new insight about their ocular health status. To the best of our knowledge, there has been no study about the ADHD–NSBVD association in the Indian population. Therefore, the aim of our study was to find out whether university students with NSBVDs also exhibited symptoms of ADHD.

Materials and Methods

Participants

This prospective cohort study was conducted at the Department of Optometry and Vision Science, Amity University, Haryana, India between May 2018 and May 2019 in accordance with the tenets of the Declaration of Helsinki after the approval of the institutional research ethics committee. One hundred university students (52% male and 48% female) with mean (± SD) age 23.13 ± 2.27 years from several different academic departments participated in the study. Participants were required to have a best-corrected distance visual acuity of 20/25 or better and near visual acuity of N6 in each eye, with no other ocular abnormalities other than binocular vision anomalies. Participants with already diagnosed learning disability or ADHD were excluded to eliminate potential bias in the measurement of ADHD-type behaviors. Participants with anisometropia >2.00 D, amblyopia, refractive error >±6.00 D, and astigmatism > 4.00 D were also excluded from the study.

This study was divided into two phases. In the first phase, a comprehensive eye examination along with a detailed binocular vision evaluation for all participants was performed by author SAD. In the second phase, author SS conducted a survey-based ADHD symptom screening for all participants. To avoid potential bias, both authors were masked about the results of either phase of the study during the data collection period.

Binocular vision assessment

A comprehensive ocular examination was performed for all participants, followed by a detailed binocular vision (BV) assessment. Spectacles were prescribed for the participants with uncorrected refractive error. Participants were advised to visit after a minimum one-month adaptation period for the BV assessment. Prior to the BV assessment, participants were asked to complete the CISS. The CISS is a self-reported fifteen-item questionnaire for the

measurement of CI symptoms. A score ≥21 in adults is significant.[22]

The following BV parameters were assessed in an illuminated room at 6 meters for distance and 33 cm for near:

- Sensory evaluation – stereopsis with Titmus fly, Worth four-dot test at distance and near
- Motor evaluation – extraocular motility, ocular alignment assessment by cover test
- Near interpupillary distance measurement (IPD) with IPD ruler
- Accommodative convergence/accommodation (AC/A) ratio with heterophoria method
- Accommodation parameters – monocular and binocular near point of accommodation (NPA) with RAF ruler, monocular and binocular accommodative amplitude (AA), positive and negative relative accommodation (PRA and NRA), monocular and binocular accommodative facility (MAF and BAF) with ± 2.00 D flipper, and dynamic retinoscopy (monocular estimation method – MEM)
- Vergence parameters – near point of convergence (NPC) with RAF ruler with

Table 1. Participants' Responses from ADHD Symptom Screening for Each of 18 Items in ASRS-v1.1.
Part A (1-6) Part B (7-18), I – Inattention, H – Hyperactivity

Item #	Item Description	Never (0)	Rarely (1)	Some-times (2)	Often (3)	Very Often (4)	Top % of Response
1(I)	How often do you have trouble wrapping up the final details of a project once the challenging parts have been done?	15%	40%	33%	11%	1%	45%
2(I)	How often do you have difficulty getting things in order when you have to do a task that requires organization?	18%	26%	39%	15%	2%	56%
3(I)	How often do you have problems remembering appointments or obligations?	18%	27%	37%	10%	8%	55%
4(I)	When you have a task that requires a lot of thought, how often do you avoid or delay getting started?	11%	35%	32%	19%	3%	22%
5(H)	How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?	13%	25%	33%	18%	11%	29%
6(H)	How often do you feel overly active and compelled to do things, like you were driven by a motor?	10%	27%	35%	21%	7%	28%
7(I)	How often do you make careless mistakes when you have to work on a boring or difficult project?	5%	25%	40%	21%	9%	30%
8(I)	How often do you have difficulty keeping your attention when you are doing boring or repetitive work?	5%	31%	28%	30%	6%	36%
9(I)	How often do you have difficulty concentrating on what people say to you, even when they are speaking to you directly?	22%	35%	30%	9%	4%	43%
10(I)	How often do you misplace or have difficulty finding things at home or at work?	17%	36%	26%	15%	6%	21%
11(I)	How often are you distracted by activity or noise around you?	5%	25%	31%	18%	21%	39%
12(H)	How often do you leave your seat in meetings or other situations in which you are expected to remain seated?	32%	43%	22%	1%	2%	25%
13(H)	How often do you feel restless or fidgety?	5%	34%	36%	21%	4%	25%
14(H)	How often do you have difficulty unwinding and relaxing when you have time to yourself?	20%	53%	17%	5%	5%	10%
15(H)	How often do you find yourself talking too much when you are in social situations?	19%	34%	27%	11%	9%	20%
16(H)	When you're in a conversation, how often do you find yourself finishing the sentences of the people you are talking to, before they can finish them themselves?	18%	25%	30%	19%	8%	57%
17(H)	How often do you have difficulty waiting your turn in situations when turn taking is required?	15%	27%	32%	18%	8%	26%
18(H)	How often do you interrupt others when they are busy?	23%	37%	23%	15%	2%	40%

accommodative target and penlight with red and green glasses, vergence facility with 12 PD base out and 3 PD base in vergence flipper, and positive and negative fusional vergence (PFV and NFV) with prism bar

The normative values for accommodation and vergence parameters and the diagnostic criteria for NSBVDs were implemented from Scheiman and Wick.[16]

ADHD symptom screening

An ADHD symptom screening was performed with the Adult ADHD Self-Report Scale-v1.1 (ASRS-v1.1) (Table 1), a symptom checklist consisting of 18 DSM-IV-TR criteria.[23] ASRS-v1.1 is divided into two parts: Part A – 6 items and Part B – 12 items. Each item explores how often a particular symptom of ADHD has occurred over the past 6 months, rated on a 5-point scale with the response options – never (0), rarely (1), sometimes (2), often (3), and very often (4). Item numbers 1 – 4 and 7 – 11 characterize symptoms of inattention, and the remaining items characterize symptoms of hyperactivity. For all 18 items, responses of "often" or "very often" are considered positive. In addition, for items 1, 2, 3, 9, 12, 16, and 18, a response of "sometimes" is also scored positive (Table 1). Six questions on Part A are used to screen ADHD. Individuals are considered at high risk for ADHD if they endorse four or more of the Part A items at these threshold levels; i.e., score ≥ 9.[4,23,24] Further investigations are recommended to those individuals to confirm the diagnosis of ADHD. Part B items are not used for ADHD diagnosis, but the items are used to predict the symptoms that ADHD patients may suffer from. The reliability and validity of ASRS-v1.1 in the adult population is well documented in the literature.[23,24]

Data analysis

Microsoft Excel 2016 and SPSS version 20.0 were used for data analysis. A Kolmogorov Smirnov test showed that outcome parameters were not normally distributed; hence, we applied non-parametric statistics. Median (IQR 1 to IQR 3) values of each outcome parameter were mentioned in the results section. The percentages of refractive errors, each type of NSBVD, responses by participants for each item in ASRS-v1.1, and participants' ADHD symptom scores from ASRS-v1.1 were calculated. A Wilcoxon–signed rank test was performed to check the difference in participants' responses between inattention category items and hyperactivity category items on the ASRS-v1.1. A Mann Whitney test was used to compare the ASRS-v1.1 scores between the participants with normal binocular vision and those with NSBVDs. The associations between ASRS-v1.1 scores and CISS scores vs binocular vision parameters were measured with Spearman rank order correlation.

Results

Status of refractive error

Forty-two percent of the participants were habitual emmetropes, and 58% had different types of refractive errors: 12% simple myopia, 19% simple myopic astigmatism, 21% compound myopic astigmatism, 3% simple hypermetropia, and 3% simple hypermetropic astigmatism. The mean spherical equivalent of refraction was -0.21 ± 0.87 D (range, -4.50 D to +0.50 D).

Status of NSBVDs

Most of the participants had an adequate level of stereopsis at 40 arc sec (40 to 42.5 arc sec). Exophoria at distance was found only in 4 participants, and near exophoria of 8 PD (6 to 8 PD) was noticed in 23 participants. Table 2 shows the median (IQR1 to IQR3) values of individual binocular vision assessment parameters. Out of 100 participants, 70% (35% male and 35% female) had various types of NSBVD: CI (30%), AI with CI (10%), AIF (9%), AI (9%), AE (6%), FVD (3%), and AE with CI (3%). Out of 100 participants, only 23% of the participants scored ≥21 on the CISS, and 17% of the participants had some form of NSBVD as well as a CISS score ≥21. There was no statistically significant association found between the CISS scores and the presence or absence of NSBVDs ($r = 0.04$, $p = 0.64$). We recommended appropriate office-based vision therapy to the participants and explained about the need for multiple sessions of vision therapy. Very few participants agreed to continue their treatment; therefore, we have not reported about the outcomes of the management of NSBVDs.

Screening for ADHD symptoms

Seventy-one percent (37% male and 34% female) of the study population scored ≥9 with Part-A items on the ASRS-v1.1. The median (IQR1 to IQR3) of ASRS score was 10 (8 to 13). According to ASRS-v1.1, "often" and "very often" responses are considered as positive for all 18 items, and the "sometimes" response is considered as positive for items 1, 2, 3, 9, 12, 16, and 18. Table 3 shows the percentage of participants' responses for each item at the positive level. Out of nine inattention symptoms, item numbers 2 (56%)

Table 2. Median (IQR1 to IQR3) Values of Accommodation and Vergence Parameters

Accommodation and Vergence Parameters		Median (IQR1 to IQR3)
Near point of convergence – accommodative target	Break	8 cm (8 to 12 cm)
	Recovery	10 cm (9.8 to 12 cm)
Near point of convergence – penlight and red/green glasses	Break	15 cm (12 to 18 cm)
	Recovery	17 cm (14 to 20 cm)
Positive fusional vergence (distance) (prism diopters-PD)	Break	20 PD (16 to 25 PD)
	Recovery	16 PD (10 to 20 PD)
Positive fusional vergence (near) (prism diopters-PD)	Break	25 PD (18 to 35 PD)
	Recovery	20 PD (15.5 to 30 PD)
Negative fusional vergence (distance)	Break	10 PD (8 to 12 PD)
	Recovery	8 PD (6 to 10 PD)
Negative fusional vergence (near)	Break	14 PD (12 to 18 PD)
	Recovery	10 PD (10 to 14 PD)
Vergence facility (with 12 PD BI / 3 PD BO flipper)		12 cpm (12 to 12 cpm)
Amplitude of accommodation (push-up test)	Right eye	10 D (8.3 to 12.5 D)
	Left eye	10 D (8.3 to 12.5 D)
	Both eyes	12.5 D (10 to 12.5 D)
Accommodative facility (with ± 2.00 D flipper)	Right eye	9.5 cpm (8 to 12 cpm)
	Left eye	10 cpm (8 to 12 cpm)
	Both eyes	10 cpm (7 to 12 cpm)
MEM retinoscopy		0.25 D (0 to 0.50 D)
Negative relative accommodation		2.5 D (2.15 to 2.75 D)
Positive relative accommodation		-3.5 D (-3.75 to -3D)

and 3(55%) demonstrated key positive responses. Out of nine hyperactivity symptoms, item no 16 (57%) demonstrated a key positive response from the participants. Out of 18 items, items in the inattention category had a greater response from the participants than the items in the hyperactivity category ($z = -2.709$, $p = 0.01$). Similar trends were noticed among the 6 items of Part A used as an ADHD screener ($z= -6.797$, $p<0.001$).

ADHD symptoms and NSBVDs

As mentioned earlier, 70% of participants revealed some form of NSBVD in the study. A high percentage (52%) with NSBVD also reported positive ADHD symptoms. However, there was no statistically significant association observed between the presence or absence of NSBVDs and positive or negative ADHD symptoms ($r = 0.11$, $p = 0.27$). With regard to the different types of NSBVD, 23% out of 30% participants with CI, 18% out of 24% participants with ADs (AI, AIF, AE), 10% out of 13% participants with accommodative with vergence dysfunctions (AVDs: AI with CI, AE with CI), and 1% out of 3% participants with FVD reported positive ADHD symptoms. Thirty percent of the study population did not demonstrate any type of NSBVD; however, 19% of them reported positive ADHD symptoms. Table 3 shows the frequency and percentage of each item's positive response from the participants under four different categories of binocular vision – CI, ADs, AVDs, and normal binocular vision (NBV). Out of 18 items on the ASRS-v1.1, participants with CI and NBV demonstrated the highest positive response for item no 16 (70% and 56.6%, respectively). Participants with ADs and AVDs showed the highest positive response for item no 3 (75%) and item no 2 (69.2%). Participants with FVD reported positive responses for items 3, 7, 8, 10, 11, and 13. Out of 6 items on Part A of the ASRS-v1.1, participants with CI and no BVDs reported the highest positive response for both item no 2 and 3 (53.3% and 46.6%, respectively). Participants with ADs and AVDs stated identical highest positive responses

Table 3. Percentage of Positive ADHD Symptoms Exhibited by Participants Associated With and Without NSBVD
Part A (1-6) Part B (7-18), I – Inattention, H – Hyperactivity

Item #	Convergence Insufficiency	Accommodative Disorders	Accommodative with Vergence Disorders	No BVD
1 (I)	14 (46.6%)	9 (37.5%)	8 (61.5%)	14 (46.6%)
2 (I)	16 (53.3%)	16 (66.6%)	9 (69.2%)	14 (46.6%)
3 (I)	16 (53.3%)	18 (75%)	6 (46.1%)	14 (46.6%)
4 (I)	10 (33.3%)	6 (25%)	1 (7.6%)	5 (16.6%)
5 (H)	7 (23.3%)	7 (29.1%)	2 (15.3%)	13 (43.3%)
6 (H)	11 (36.6%)	4 (16.6%)	8 (61.5%)	5 (16.6%)
7 (I)	8 (26.6%)	8 (33.3%)	3 (23.1%)	10 (33.3%)
8 (I)	13 (43.3%)	10 (41.6%)	3 (23.1%)	9 (30%)
9 (I)	15 (50%)	13 (54.1%)	7 (53.8%)	8 (26.6%)
10 (I)	5 (16.6%)	5 (20.8%)	2 (15.3%)	8 (26.6%)
11 (I)	14 (46.6%)	10 (41.6%)	6 (46.1%)	7 (23.3%)
12 (H)	10 (33.3%)	7 (29.1%)	4 (30.7%)	4 (13.3%)
13 (H)	10 (33.3%)	8 (33.3%)	2 (15.3%)	4 (13.3%)
14 (H)	1 (3.3%)	4 (16.6%)	3 (23.1%)	10 (33.3%)
15 (H)	7 (23.3%)	5 (20.8%)	1 (7.6%)	7 (23.3%)
16 (H)	21 (70%)	11 (45.8%)	8 (61.5%)	17 (56.6%)
17 (H)	10 (33.3%)	9 (37.5%)	3 (23.1%)	4 (13.3%)
18 (H)	13 (43.3%)	6 (25%)	6 (46.1%)	15 (50%)

for all 18 items as well as for the 6 items of Part A of the ASRS-v1.1.

ASRS score and NSBVDs

The median (IQR1 to IQR3) ASRS scores for participants with NSBVD, 10 (9 to 13), and with NBV, 9 (6 to 12.5), were not statistically significantly different ($p = 0.3$). The intergroup comparison of median (IQR1 to IQR3) ASRS scores [CI: 9.5 (9 to 12), ADs: 10 (8.75 to 13), AVDs: 12(9 to 13), and NBV: 9 (6 to 12.5)] exhibited no statistically significant difference ($p = 0.5$). There was no significant association observed between the ASRS scores and the status of NSBVDs ($r = -0.1$, $p = 0.3$). No association was noted between the ASRS scores and binocular vision assessment parameters like NPC, NPA, and AF ($r \leq 0.1$, $p \geq 0.2$ for all). However, a moderately significant association was noticed between the ASRS scores and the CISS scores ($r= 0.3$, $p= 0.03$).

Discussion

In this study, we assessed the percentage of positive ADHD symptoms exhibited by university students who also showed some form of NSBVD. To the best of our knowledge, this is the first study that comprehensively evaluated the association between ADHD symptoms and the status of NSBVDs among university students in India. Seventy percent of participants had some form of NSBVD in this study. Previous literature reported a wide range of prevalence (4% to 73%) of NSBVDs among university students.[20,21,25] This wide variation might be due to the number of diagnostic criteria for NSBVDs used by different studies. CI was the most common type of NSBVD in our study, which was consistent with the findings by Garcia-Munoz et al.[21] The percentage of CI was 30% in this study, which was comparable with the studies by Ovenseri-Ogbomo et al.[26] and Moon B-Y et al.,[27] who reported 29.6% and 21.2%, respectively, among university students. According to the CISS score, most of the participants with NSBVDs were asymptomatic in this study, which is somewhat consistent with the findings by Horwood et al.[28]

According to a review article by Dupaul et al., the approximate prevalence of ADHD symptoms in university students was 2% to 8%; however, they suggested further study on a larger scale.[2] Recent

studies by Garnier-Dykstra et al., Fuller-Killgore et al., Kavakci et al., Mosalanjed et al., and Kwak et al. reported 10.3%, 12.6%, 10.1%, 15.4%, and 7.6% prevalence of ADHD symptoms among university students, repectively.[3–7] We found a higher percentage (71%) of participants who reported positive ADHD symptoms with ASRSv1.1. However, direct comparison of the results from previous studies with ours is not possible due to the difference in the ADHD symptom screening tool used and in the diagnostic criteria for ADHD. Multiple[2,3,6] and single[4,5,7] ADHD symptom screening tools were used in previous studies. Kwak et al.[5] and Migrant et al.[18] used a single screening tool, the ASRSv1.1, as we used in this study.

In our study, participants provided more positive responses to the items in the inattention category than to the items in the hyperactivity category. This was consistent for all 18 items of the ASRS-v1.1 and for the 6 items of the Part-A ADHD screener. This was expected as 70% of participants were diagnosed with different types of NSBVD, where CI (30%) was most prevalent. Borsting et al. hypothesized that CI and accommodative dysfunctions are consequences of an inadequate attention processing mechanism.[10] Individuals with CI mainly complain of inattention problems.[29] A reduction of those attention problems was noticed in symptomatic CI children after treatment with office-based vision therapy.[15] We observed that 52% of participants had NSBVDs and reported positive ADHD symptoms. In addition, there was a moderate association noted between the CISS scores and ASRS-v1.1 scores. Therefore, the large prevalence (71%) of positive ADHD symptoms and the higher percentage of positive responses on the items in the inattention category in this study might be a consequence of the presence of NSBVDs among the participants. Although there was a difference in the study population, the results of our study were to some extent consistent with the findings by Borsting et al.[10,15,29] ASRS-v1.1 was the only ADHD symptom screening tool in our study. We did not compare the outcomes of our ADHD screening with other screening tools like Conners' Adult ADHD Rating Scale–Self-Report: Long Version (CAARS) or the Brown ADD Scales as that was not the aim of our study. We already had an extended study protocol, so it was impossible to apply multiple ADHD symptom screening tools. Also, we failed to repeat the ADHD screening with ASRS-v1.1 due to the unavailability of participants for multiple sessions of office-based vision therapy.

Fifty-two percent (23% CI, 18% ADs, 10% AVDs, and 1% FVD) of participants had NSBVDs with positive ADHD symptoms. A modest correlation was found between the ASRS-v1.1 and CISS scores. This is consistent with the finding reported by Migrant et al., who also observed that ASRS-v1.1 scores, CISS scores, and ARHQ scores for dyslexia screening were well correlated.[18] Wilmer et al. indicated that oculomotor imbalance, mainly near phoria after near work, might have an impact on predicting ADHD-like behaviors in college students.[12] This finding is somewhat consistent with the present study finding, as we also found ADHD symptoms in university students associated with NSBVDs, which is one consequence of oculomotor imbalance due to excessive near and intermediate work. We investigated the association between all types of NSBVD and ADHD symptoms, which rendered our study unique from Migrant et al. and Wilmer et al., as they particularly focused on CI[18] and near phoria,[12] respectively.

The association between the NSBVDs, particularly CI and ADHD, in school-age children has already been well documented.[10,15,17,30] Rouse et al.[17] and Elsayed et al.[14] recommended that children with parent- or teacher-reported ADHD must undergo an evaluation for CI to avoid misdiagnosis.[9] Borsting et al. and Lee et al. observed a reduction of ADHD behaviors in children with CI after undergoing multiple sessions of vision therapy.[15,30] However, these findings are not directly comparable to the results of the present study because of different study populations, different ADHD screening tools, and differences in the study protocols. However, based on the findings from the CI-ADHD association studies in the school-age population[10,15,30] and from the retrospective study on the CI-ADHD relationship (age group 6 to 51 years) by Granet et al.,[11] we can state that after appropriate management of NSBVDs, further ADHD symptom screening in the present study population may be useful to determine the actual prevalence of positive ADHD symptoms. This will be helpful to create an awareness among college students and teachers that any student with inattentive or hyperactive-like behavior must undergo a comprehensive eye examination along with a detailed assessment of binocular vision in order to rule out the presence or absence of CI.

The present study had the following limitations:

- The study sample size was relatively small for investigating the association NSBVDs and ADHD among university students.

- After receiving the management for NSBVD in the first visit, none of the participants returned to the clinic for follow-up. We explained the steps of management of NSBVDs, but somehow, they lost interest, perhaps due to the vast study protocol.
- Repeat ADHD symptom screening was not possible due to the unavailability of the participants for follow-up.
- We have not assessed the academic behavior of the participants.

Conclusion

We would like to summarize that university students with NSBVDs can also exhibit ADHD symptoms. There is a chance of misdiagnosis of NSBVDs, particularly CI, as ADHD in university students. Similarity of the symptoms between ADHD and NSBVDs is the most important reason for misdiagnosis. Therefore, we suggest a complete binocular vision evaluation for university students with ADHD-like behavior particularly with inattention problems. A further study on the comparison of ADHD symptoms before and after the management of NSBVDs in a large sample of university students is recommended.

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